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PATENT APPLICATION

Case Docket No. 200-0646

Date: July 5, 2000

Sir:

Transmitted herewith for filing is the patent application of Inventor(s):

Juliet Kraal  
Daniel ArbitterFor: **SYSTEM AND METHOD OF SUBJECTIVE EVALUATION OF A VEHICLE DESIGN WITHIN A  
VIRTUAL ENVIRONMENT USING A VIRTUAL REALITY**

Enclosed are:

- ☒ 5 sheet(s) of drawings  
☒ Assignment and Cover Sheet  
☒ Information Disclosure Statement, PTO Form 1449, and Copies of Citations  
☐ A certified copy of

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Application 60/ filed April 14, 2000.

## 15

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### Description of the Related Art

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5 of a proposed design, versus preparing an actual  
vehicle model.

10 subjective and objective occupant compartment  
criteria for aesthetics and human factors. Objective  
criteria include packaging and fit of a system or  
component within the vehicle. However, to fully meet  
or exceed a consumer's expectations of a vehicle,  
15 subjective criteria, including comfort, convenience,  
visibility and accessibility are considered.

20 analyzed in two dimensions, which requires many iterations of a drawing. A three-dimensional physical model, also referred to as a mockup, may be constructed to obtain a better perspective of the design. The mockup may be subjected to testing to

determine whether it complies with objective and subjective criteria. For example, subjective criteria can be evaluated by positioning an evaluator within the mockup and having the evaluator respond to  
5 predetermined questions concerning the comfort and feel of various aspects of the mockup. This design method is time consuming and expensive, since it requires a physical model and evaluators from a target population.

10           It is also known to utilize virtual reality technology in conjunction with a digital mockup of a vehicle design to evaluate a proposed design. Virtual reality technology enables an evaluator to view an image of a virtual environment from a virtual human's  
15 perspective, and function within the virtual environment. Virtual reality also includes the personal immersion of the evaluator in the virtual environment, so that the evaluator can experience the virtual environment. The use of virtual reality  
20 technology in conjunction with a digital mockup of a vehicle design enhances the quality, robustness, reliability and cost-effectiveness of the design.

An example of the use of virtual reality technology in the design of a vehicle is disclosed in

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5 design is disclosed in U.S. Patent Number 5,583,526  
to Socks et al, entitled "Hand Calibration System For  
Virtual Reality Vehicle Simulator."

While both of the above referenced virtual reality vehicle simulators work well, only an eye and hand of the evaluator is immersed within the virtual environment. Therefore, the use of such a virtual reality vehicle simulator is limited to studies involving an evaluator's hand and view. Also, since only a portion of the evaluator is immersed in the virtual environment, the evaluator is physiologically less connected to the virtual environment than if the rest of their body was present. Thus, there is a need in the art for a system and method of subjective evaluation of a vehicle design that immerses a digital occupant into a virtual vehicle environment, so that the evaluator can subjectively assess the vehicle from their own perspective, or from a scaled perspective of a member of a target population.

### Summary Of The Invention

Accordingly, the present invention is a system of subjective evaluation of a vehicle design within a virtual environment using virtual reality.

- 5 The system includes a scaleable physical property representative of the vehicle design, such that the physical property is adjusted according to a scale ratio for an evaluator of the vehicle design. The system also includes a computer system for digitally
- 10 creating a virtual environment having a virtual human immersed within. The system further includes a motion capture system for sensing a motion of the evaluator and communicating the sensed motion of the evaluator to the computer system and a virtual
- 15 reality display mechanism operatively communicating with the computer system, for providing the evaluator a view of the virtual environment while evaluating the vehicle design.

- Also, the present invention is a method of
- 20 subjective evaluation of a vehicle design within a virtual environment using virtual reality. The method includes the steps of preparing an evaluator of a vehicle design for immersion as a virtual human in the virtual environment and determining a scale ratio

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for the evaluator. The method also includes the steps of preparing an adjustable property using the vehicle design and the scale ratio. The method further includes the steps of growing the virtual human within the virtual environment to virtually represent a scaled evaluator, and aligning the virtual human in the virtual environment with the evaluator and the property. The method still further includes the steps of performing the evaluation of the vehicle design by the evaluator and using the evaluation of the vehicle design in the design of the vehicle.

One advantage of the present invention is that a system and method of subjective evaluation of a vehicle design within a virtual environment is provided that utilizes virtual reality technology in the design of a vehicle to study subjective aspects of consumer and vehicle interaction, without building an actual prototype. Another advantage of the present invention is that the system and method personally immerses a digital human representing the full-body of an evaluator into a virtual vehicle environment. Still another advantage of the present invention is that the system and method scales the

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20                    Other features and advantages of the  
present invention will be readily appreciated, as the  
same becomes better understood after reading the  
subsequent description taken in conjunction with the  
accompanying drawings.



### Brief Description Of The Drawings

FIG. 1 is a block diagram of a system for subjective evaluation of a vehicle design within a virtual environment, according to the present invention.

FIG. 2 is a flowchart of a method of subjective evaluation of a vehicle design within a virtual environment, according to the present invention, for the system of FIG. 1.

FIGS. 3A through 3D are block diagrams illustrating a scale perspective between a physical world and a virtual world.

FIG. 4 is a block diagram of a physical prop for the system of FIG. 1.

FIG. 5 is a flowchart of a process for growing a digital human and constraining the digital human to the evaluator, according to the present invention, for the method of FIG. 2.

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### Description Of The Preferred Embodiment(s)

Referring to FIG. 1, one embodiment of a system 10, according to the present invention, for subjective evaluation of a vehicle design by

immersing a digital occupant within a virtual environment is illustrated. Advantageously, the system 10 can be utilized to evaluate a vehicle design based on a consumer's perception of ergonomic factors such as visibility, reach and clearance, early in the design process.

The system 10 includes an adjustable physical property 12 or prop that simulates the vehicle design being evaluated. In this example, the adjustable prop 12 includes a seat 14, a floor 16, a foot control 18, and a steering wheel 20. Key reference points from the vehicle design are utilized to position the seat 14, floor 16, foot control 18 and steering wheel 20 to simulate the vehicle design. The seat 14 can accommodate a seated occupant 24.

Referring to FIG. 4, an example of a key reference point for representing a particular vehicle design is illustrated for the prop 12. An H-point, shown at 22, which is representative of a position of a pivot center of a torso and thigh of a drafting template used in defining a seat 14. Another reference point is a heel point, as shown at 26. The heel point 26 is a fixed position of a manikin heel (not shown) of the seated occupant 24 on the floor 16

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The system 10 includes a motion capture system 34 strategically positioned on the evaluator 32 to sense the movement of the evaluator 32. Motion capture is also used to operate a virtual human 36 in real time. The accuracy and precision of a digital occupant study depends on the virtual human 36, to be described, mirroring the movements of the evaluator 32. The reflection of the evaluator's movements is a component of the personally immersive experience, which also increases the fidelity of the simulation and the evaluator's confidence in the study.

The motion capture system 34 includes a motion capture sensor 38, such as a magnetic spatial tracker. Various factors influence the strategic placement of the motion sensors on the evaluator 32 including comfort to the wearer, reproducible sensor locations and a reproducible evaluator posture. In this example, eleven motion sensors are strategically positioned on the evaluator 32 to track the evaluator's movements. For example, motion capture sensors 38 are located on the evaluator's foot, above a knee, lower back, upper back, above an elbow, on a

back of the hand and above a head. It should be appreciated that the same ergonomic landmarks should be used in positioning the motion capture sensors 38 on each evaluator, to ensure the accuracy of the  
5 evaluation. It should also be appreciated that the motion capture sensors 38 are in communication with a computer system 46, to be described, to provide motion capture sensor positions and orientations, in a manner to be described.

10           The motion capture system 34 further includes an instrumented glove 44, as is known in the art, that captures the motion of the evaluator's hand. An example of an instrumental glove 44 is Cybergloves by Virtual Technologies, Inc. The  
15 instrumented glove 44 is operatively in communication with the computer system 46, in a manner to be described.

          The system 10 also includes a virtual reality display system 40, such as a head mounted  
20 display mechanism, known in the art. The virtual reality display mechanism 40 is worn by the evaluator 32, and allows the evaluator 32 to "see" a virtual environment 42 through the eyes of the virtual human  
36. An example of a virtual reality display

mechanism 40 is PUGO by Kaiser Electro Optics. The virtual reality display mechanism 40 is in communication with the computer system 46, and provides the evaluator 32 a view through the virtual human's eyes, or a first person view of the virtual environment 42.

The system 10 includes a computer system 46, as is known in the art, to implement a method, to be described, of subjective evaluation of a vehicle design using virtual reality within a virtual environment 42. The computer system 46 includes a processor 48 having a memory 48a to process information relevant to the evaluation of the vehicle design. The computer system 46 includes a display device 50, such as a video terminal, to display information regarding the evaluation. It should be appreciated that, in this example, a plurality of video terminals are utilized to display information.

For example, a first video terminal 52 provides a display of information regarding the evaluation, such as instructions to control the study. A user 54 inputs information into the computer system 46 when prompted to do so. Selection and control of the information within a screen can be

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achieved by the user 54, via a user interactive device, such as a keyboard or mouse. The set of parameters or the set of instructions may be specific to the evaluation, wherein other data and information  
5 non-specific to the evaluation may already be stored in the memory of the computer system. One example of an input method is a pop-up dialog box containing available information or instructions. For example, information may be representative of a scale for the  
10 evaluator 32, or different vehicle design alternatives.

The computer system 46 also includes a second video terminal 56 that displays information regarding the evaluation, such as a first person view  
15 58 of the virtual environment 42 or a third person view 60 of the virtual human 36 within the virtual environment 42. Advantageously, these views 58, 60 can be displayed on one screen or in a series of screens.

20 The computer system 46 also includes a remote video terminal 62 that allows observers, such as a design team 64 responsible for the vehicle design, to view the evaluation. In this example, there are two remote video terminals 62, one provides

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a first person view 58 of the evaluation and the other provides a third person view 60 of the evaluation. Advantageously, the design team 64 can actively participate in the evaluation to better  
5 understand and analyze the data generated by the evaluation. For example, the design team 64 can watch for an interference between the virtual human 36 and a portion of a digital vehicle 41 within the virtual environment 42 while the evaluator 32  
10 executes an instruction.

The computer system 46 utilizes the set of information or instructions from the user 54 and any other information in carrying out a method 70, according to the present invention and discussed in  
15 detail subsequently, of subjective evaluation of a vehicle design within a virtual environment.

Advantageously, the computer implemented method 70 of subjective evaluation of a vehicle design using virtual reality combines all of the  
20 foregoing to provide an efficient, flexible, rapid tool for subjectively evaluating the design of a vehicle from a consumer's perspective. Furthermore, data obtained during the subjective evaluation of the



design is an output of the method 70 and is available for further analysis and study.

Referring to FIG. 2, a method 70 according to the present invention, of subjective evaluation of a vehicle design using virtual reality is illustrated. The evaluator 32 immersed in a virtual environment expects the same visual feedback from the virtual environment as in the physical environment. Therefore, the method 70 provides for personal immersion of the evaluator 32 into a virtual environment 42 that includes a full-body, real time dynamic digital representation of the individual being immersed. The method begins in block 100 and continues to block 105.

In block 105, the design team 64 prepares a subjective evaluation of the vehicle design, including criteria for performing the evaluation. It should be appreciated that the subjective evaluation may be in the form of a questionnaire for an evaluator 32 that is administered while the evaluator 32 is immersed in the virtual environment 42. An example of a subjective evaluation is an ergonomic evaluation of the placement of controls within a reach zone. Still another example of a subjective

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In block 120, the prop 12 is adjusted to be  
15 representative of the same dimensional relationships  
as the digital vehicle design for the evaluation.  
For example, the prop's seat 14 and steering wheel 20  
have the same geometric relationship as the digital  
vehicle. The prop 12 is also checked to determine if  
20 there is sufficient range to adjust the prop 12 based  
on the maximum and minimum scale ratio of the target  
population, for a scaled study. The methodology  
advances to block 125.



from the point of view of a member of the target population.

As shown in FIG. 3A, in a 1:1 scale, a physical human 80a views the physical environment, which in this example is a shelf 82a, from the same perspective as a virtual human 84a immersed within a virtual environment 86a. Advantageously, a 1:1 scale perspective allows the evaluator 32 to apply their individual experiences to the digital vehicle 41 represented in the virtual world. FIG. 3B illustrates a 1:1 scale with the shelf 82b positioned lower. Like reference numbers are used for like parts in FIG. 3A. As shown in FIG. 3C, for a 1:.9 scale, an evaluator 80c experiences the virtual environment of a shelf 86c from the perspective of a virtual human 84c one tenth shorter than the actual size of the evaluator 80c. It should be appreciated that the shelf 86c moves upwards in a vertical direction to simulate the perception of a shorter individual. As shown in FIG. 3D for a 1:1.1 scale, the evaluator 80c experiences a virtual environment 86d from the perspective of a virtual human 84d one tenth taller than the actual size of the evaluator 80d. Likewise, the shelf 86d moves downwards in a

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vertical direction to simulate the perception of a taller individual. The methodology advances to block 135.

In block 135, the design team 62 measures the evaluator's 32 key anthropometric dimensions for the specified study. The anthropometric dimensions, as is understood in the art, are ergonomically recognized dimensions identified by ergonomic experts and used to relate the sizes of various members of a target population. Examples of anthropometric dimensions includes height, seated eye height, arm length, leg length and knee to hip length. The methodology advances to block 140 and continues.

In block 140, the methodology determines a scale ratio for the evaluator 32 based on the scale perspective, a selected anthropometric dimension of the evaluator 32 and a similar anthropometric dimension of the target population. The methodology advances to block 145 and the prop 145 is adjusted based on the scale ratio for the evaluator 32. Advantageously, the evaluator experiences the prop from the point of view of an individual the size of the scale perspective. The methodology advances to block 147.

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vehicle 41 in the virtual environment 42. Another example of a key reference point is a ground plane (not shown), and the virtual human 36 is located by registering the digital feet to the ground plane. The methodology advances to block 155.

In block 155, the evaluator 32 is immersed in the virtual environment 42. The positioning of the evaluator 32 relative to the prop 12 is based on a predetermined reference point. For example, the hip point 22 is used to locate the hip center of the evaluator 32 while seated in the seat 14. For a standing or walking study outside the vehicle, the virtual human 36 is located by registering the digital feet to a ground plane. Advantageously, the evaluator 32 sees the view of the virtual environment 42 through the virtual human's eye. The evaluator 32 can control a movement of the virtual human 36 through their own movements, as captured by the full-body motion capture system. It should be appreciated that the steps of preparing the evaluator 32, prop 12, and digital vehicle, and growing the virtual human 36 and registering with the physical and virtual environments need not be accomplished in the order shown in FIG. 2, but can be

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done in another order including concurrently. The methodology advances to block 160.

In block 160, the evaluation is performed by the user 54, design team 64 and evaluator 32. An example of an evaluation is a visibility study that evaluates various pillar 68 design alternatives for the digital vehicle to determine which trim design would yield optimum exterior visibility. Another example of an evaluation is a vehicle interior visibility study to assess visual obscuration of an instrument panel display (not shown). A further example of an evaluation is a reach study that considers the accessibility and positioning of controls on the instrument panel. The evaluation typically includes questions or instructions from the design team 64 or user 54 that request the evaluator 32 to perform an activity, such as look out a side window (not shown) for the visibility study or reach for a radio control knob (not shown) for the reach study. It should be appreciated that real time collision detection can be used in the study. For example, a reach study of the virtual radio control knob may include a collision detection mechanism (not shown) as is understood in the art, to alert the

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In diamond 165, the design team 64 determines whether to perform another evaluation. If the design team 64 determines to perform another evaluation, the methodology advances to diamond 170 and determines if the new evaluation will be performed with a new evaluator 32. If the new evaluation will be performed with a new evaluator 32, the methodology returns to block 125 and continues. Returning to diamond 170, if the design team 64 determines not to perform the new study with a new evaluator 32, the methodology advances to diamond 175.

In diamond 175, the design team 64 determines whether to revise the scale ratio. If the design team determines not to revise the scale ratio, the methodology returns to block 160. Returning to diamond 175, if the design team 64 determines to revise the scale ratio, the methodology advances to diamond 180. In diamond 180, the design team 64 determines whether to use different key anthropometric dimensions for either the study or the evaluator 32. If the design team determines to use different predetermined anthropometric dimension for the evaluator 32, the methodology returns to block



looking straight ahead. It should be appreciated that the evaluator 232 has strategically placed motion capture sensors 238 as previously described. In step 1b, concurrent with step 1a, the computer system 46  
5 uses a signal from the motion capture sensors 238 on the evaluator 232 to digitally establish the motion capture sensor locations for the virtual human 236, as shown at 280. Critical dimensions between the sensors 238 may also be measured, such as height,  
10 elbow width, leg length, or knee to ankle length.

In step 2a, the evaluator 232 relaxes, while concurrently in step 2b the computer system 46 digitally creates a virtual human 236 in space, based on the measurements between the motion capture  
15 sensors 238 and dimensions from the evaluator 232, including weight, height and limb lengths. It should be appreciated that in this example, the virtual human 236 is modeled after the Jack human model, as is known in the art. The Jack human model is a full-  
20 body, real-time interactive model of a human that has realistic joint constraints, behavior models and an inverse kinematic engine that provides real time solutions. These characteristics render the Jack human model of the digitally created virtual human

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236 fully controllable in real-time, and minimizes the number of motion capture sensors 238 worn by the evaluator 232. The Jack human model uses realistic joint constraints and spine behavior model so that movement of the virtual human's spine can be sufficiently controlled by two motion capture sensors 238.

To digitally grow the virtual human 236, the motion sensor locations on the anthropometric landmarks of the evaluator 232 and corresponding sites on the virtual human 236 are used. Stature is obtained by using vertical difference equations, and the girth of the digital human 236 is calculated by applying the horizontal distance between an elbow motion capture sensor 238 and the evaluator's weight. The resulting virtual human 236 has the height, limb length and limb proportions of the evaluator 232. The virtual human 236 can be modified for a scaled study by applying the scale ratio. Advantageously, the scaled virtual human 236 has similar limb proportions to the physical human evaluator 232 represented by the scaled perspective.

In step 3a, the evaluator 232 reassumes the initial posture from step 1a to align the virtual

human 236 to the evaluator 232. In step 3b,  
concurrent with step 3a, the virtual human 236 is  
aligned with the evaluator 232, so that the virtual  
human 236 and evaluator 232 have the same posture in  
5 the virtual and physical environments. Constraints  
are established to relate the motion capture sensors  
238 on the evaluator 232 with the digital sensor  
locations 280. Thus, the constraints force the  
digital sensor locations 280 to follow the motion  
10 capture sensors 238.

In step 4a, the evaluator 232 moves.  
Concurrently, in step 4b the virtual human 236  
mirrors the evaluator's movements. The constraints  
force the digital sensor locations 280 to mirror the  
15 position of the motion capture sensors 238 worn by  
the evaluator 232. Advantageously, the full body of  
the evaluation 232 is digitally represented by the  
virtual human 236 in the virtual environment 42, and  
the motions of the evaluator 232 are digitally  
20 represented by the virtual human 236 in the virtual  
environment 42.

The present invention has been described in  
an illustrative manner. It is to be understood that  
the terminology, which has been used, is intended to

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be in the nature of words of description rather than  
of limitation.

Many modifications and variations of the  
present invention are possible in light of the above  
5 teachings. Therefore, within the scope of the  
appended claims, the present invention may be  
practiced other than as specifically described.

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**What is Claimed Is:**

1/ A system for subjective evaluation of a vehicle design within a virtual environment using virtual reality comprising:

- 5 a scaleable physical property representative of the vehicle design, wherein the physical property is adjusted according to a scale ratio for an evaluator of the vehicle design;
- 10 a computer system for digitally creating a virtual environment having a virtual human immersed within, wherein the virtual environment includes the vehicle design and the virtual human virtually represents a scaled evaluator;
- 15 a motion capture system for sensing a motion of the evaluator and communicating the sensed motion of the evaluator to the computer system, so that the motion of the evaluator controls the motion of the virtual human in the virtual environment; and
- 20 a virtual reality display mechanism operatively communicating with the computer system, for providing the evaluator a view of the virtual environment while evaluating the vehicle design.

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2. The system of claim 1 wherein the motion capture system includes an instrumented glove worn by the evaluator for sensing motion of the evaluator's hand.

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3. The system of claim 1 wherein the motion capture system includes magnetic spatial tracking sensors located on the evaluator for sensing motion of the evaluator's full body.

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4. The system of claim 1 wherein the virtual reality display mechanism includes a head mounted display mechanism worn by the evaluator for seeing the virtual environment through an eye of the virtual human.

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5. The system of claim 1 wherein the computer system includes at least one video terminal displaying a view of the virtual environment as seen through an eye of the virtual human.

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6. The system of claim 1 wherein the computer system includes at least one video terminal

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displaying a third person view of the virtual human immersed within the virtual environment.

7. A method as set forth in claim 1,  
5 wherein the scale ratio is a ratio between a predetermined dimension of the evaluator and a predetermined dimension of a member of a target population.

10 ~~8.~~ A method of subjective evaluation of a vehicle design within a virtual environment using virtual reality, said method comprising the steps of:  
preparing an evaluator of a vehicle design for immersion as a virtual human in the virtual  
15 environment, wherein the virtual environment is created within a computer system and includes the vehicle design;

determining a scale ratio for the evaluator, wherein the scale ratio is a ratio between  
20 a predetermined dimension of the evaluator and a predetermined dimension of a member of a target population;

preparing an adjustable property using the vehicle design and the scale ratio;

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growing the virtual human within the  
virtual environment to virtually represent a scaled  
evaluator;

aligning the virtual human in the virtual  
5 environment with the evaluator and the property,

performing the evaluation of the vehicle  
design by the evaluator; and

using the evaluation of the vehicle design  
in the design of the vehicle.

10

9. A method as set forth in claim 8  
wherein said step of preparing an evaluator includes  
the step of measuring an anthropometric dimension of  
the evaluator.

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10. A method as set forth in claim 8  
wherein said step of preparing an evaluator includes  
the step of positioning a motion capture system on  
the evaluator for sensing a motion of the evaluator  
20 and communicating the sensed motion of the evaluator  
to the computer system, so that the motion of the  
evaluator controls the motion of the virtual human in  
the virtual environment.

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evaluator and communicating the sensed motion of the evaluator to a computer system, so that the motion of the evaluator controls the motion of the virtual human in the virtual environment;

5           providing the evaluator with a virtual reality display mechanism operatively communicating with the computer system, for providing the evaluator a view of the virtual environment while evaluating the vehicle design

10           determining a scale ratio for the evaluator wherein the scale ratio is a ratio between a predetermined dimension of the evaluator and a predetermined dimension of a member of a target population;

15           adjusting the property using the scale ratio for the evaluator;

            growing the virtual human in the virtual environment using the measurements of the evaluator and the scale ratio to virtually represent a scaled  
20 evaluator;

            aligning the virtual human in the virtual environment to the evaluator and the property;

            performing the evaluation of the vehicle design by the evaluator; and

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using the evaluation of the vehicle design  
in the design of the vehicle.

16. A method as set forth in claim 15,  
5 including the step of determining whether to perform  
a new evaluation and performing a new evaluation if  
determined to perform a new evaluation.

17. A method as set forth in claim 16  
10 including the step of determining whether to use a  
new evaluator and using a new evaluator if determined  
to use a new evaluator.

18. A method as set forth in claim 17  
15 including the step of determining whether to revise  
the scale ratio if determined not to use a new  
evaluator and revising the scale ratio if determined  
to revise the scale ratio.

20 19. A method as set forth in claim 15  
wherein said step of growing the virtual human  
includes the steps of:

assuming an initial posture by the  
evaluator;

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digitally establishing locations of motion capture sensors positioned on the evaluator in the initial posture using a computer system;

creating a virtual human digitally using  
5 the motion capture sensor locations for the virtual human and the scaled measurements of the evaluator;  
aligning the virtual human with the evaluator, wherein the motion capture sensor locations on the virtual human are aligned with the  
10 motion capture sensor locations on the evaluator; and  
checking that the motion of the virtual human mirrors the motion of the evaluator.

20. A method as set forth in claim 15,  
15 including the step of determining a scale ratio range for a member of a target population represented in the evaluation and using the scale ratio range to determine adjustability of the property.

### Abstract Of The Disclosure

A system for subjective evaluation of a vehicle design within a virtual environment includes a scaleable physical property representative of the vehicle design, such that the physical property is adjusted according to a scale ratio for an evaluator of the vehicle design. The system also includes a computer system for digitally creating a virtual environment having a virtual human immersed within. The system further includes a motion capture system for sensing a motion of the evaluator and communicating the sensed motion of the evaluator to the computer system and a virtual reality display mechanism operatively communicating with the computer system, for providing the evaluator a view of the virtual environment while evaluating the vehicle design. The method includes the steps of preparing an evaluator of a vehicle design for immersion as a virtual human in the virtual environment and determining a scale ratio for the evaluator. The method also includes the steps of preparing an adjustable property using the vehicle design and the

scale ratio. The method further includes the steps  
of growing the virtual human within the virtual  
environment to virtually represent a scaled  
evaluator, and aligning the virtual human in the  
5 virtual environment with the evaluator and the  
property. The method still further includes the  
steps of performing the evaluation of the vehicle  
design by the evaluator and using the evaluation of  
the vehicle design in the design of the vehicle.

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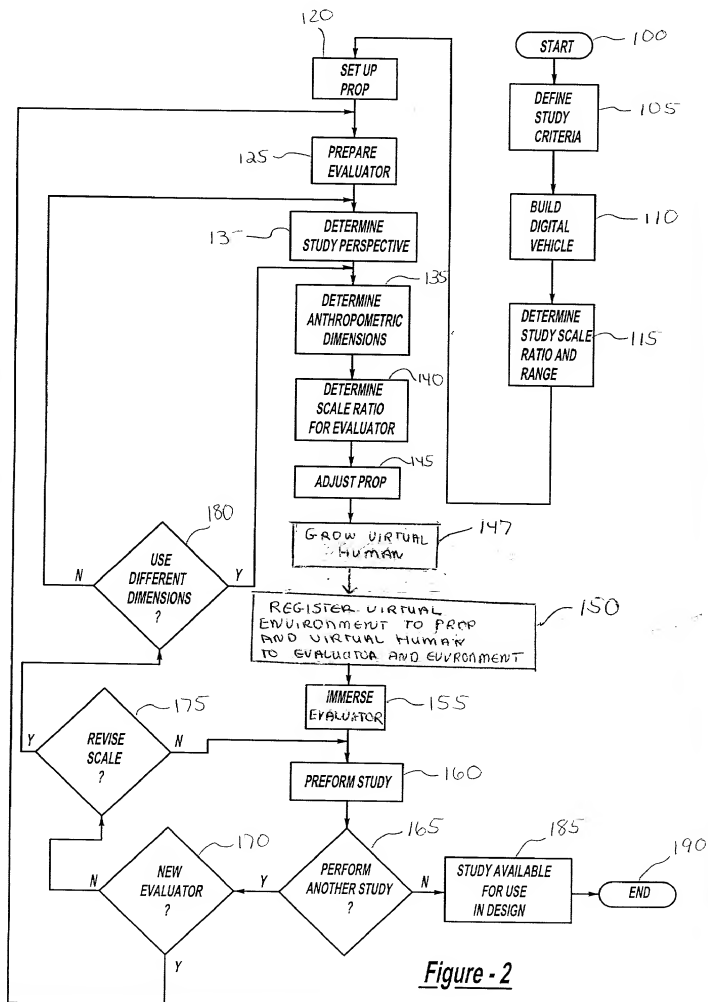


Figure - 2

Figure - 3A

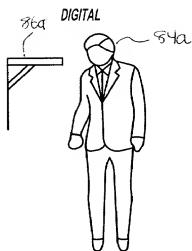
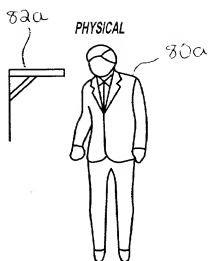


Figure - 3B

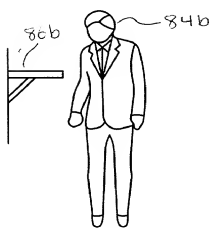
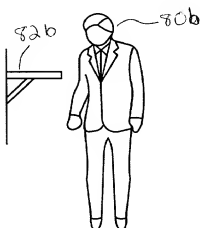


Figure - 3C

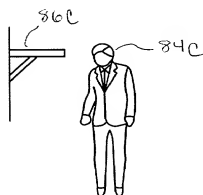
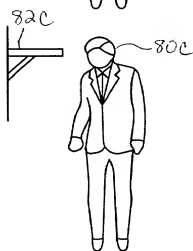
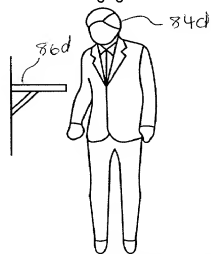
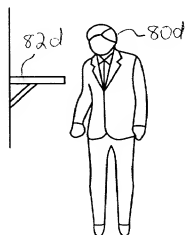
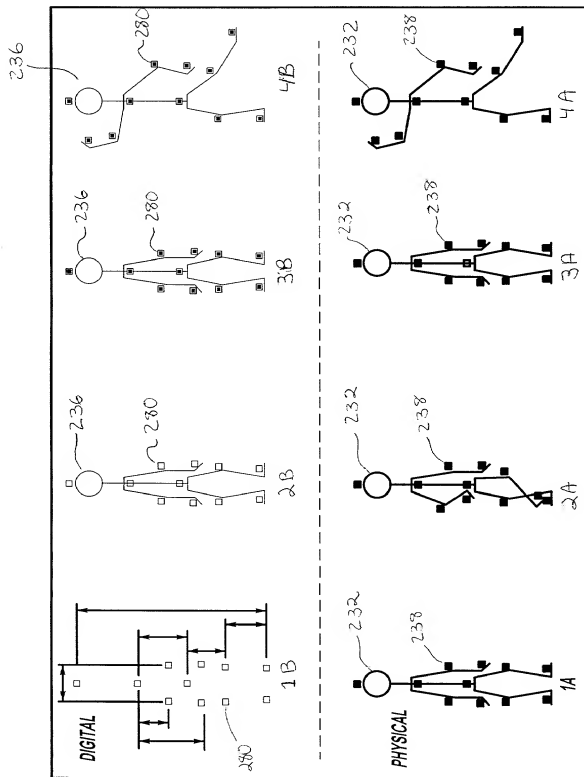


Figure - 3D





Figure - 5



**DECLARATION AND POWER OF ATTORNEY - ORIGINAL APPLICATION****Attorney's Docket No.  
200-0646**

As a below named inventor, I hereby declare:

My residence, post office address and citizenship are as stated below next to my name;

I verily believe I am the original, first and sole inventor or an original, first and joint inventor of the subject matter that is claimed and for which a patent is sought on the invention entitled

**SYSTEM AND METHOD OF SUBJECTIVE EVALUATION OF A VEHICLE DESIGN WITHIN A VIRTUAL ENVIRONMENT USING A VIRTUAL REALITY**

the specification of which is attached hereto.

I have reviewed and understand the contents of the specification identified above, including the claims.

I acknowledge my duty to disclose information of which I am aware that is material to the examination of this application in accordance with Section 1.56(a), Title 37 of the Code of Federal Regulations; and

as to application for patents or inventor's certificate on the invention filed in any country foreign to the United States of America, prior to this application by me or my legal representatives or assigns,

☒ no such applications have been filed, or

☐ such applications have been filed as follows

COUNTRY	APPLICATION NO.	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application Number) (Filing Date) (Status - patented, pending, abandoned)

(Application Number) (Filing Date) (Status - patented, pending, abandoned)


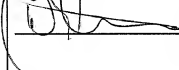
**POWER OF ATTORNEY:** As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the United States Patent and Trademark Office connected therewith and to act on my behalf before the competent International Authorities in connection with any and all international applications filed by me. (List name and registration number)

Daniel H. Bliss - 32,398  
David B. Kelley - 33,718  
Roger L. May - 26,406

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Troy, MI 48064 Phone: 248 - 649-6090

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

NAME AND POST OFFICE ADDRESS OF INVENTOR:	RESIDENCE	CITIZENSHIP	SIGNATURE	DATE
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